(8-89)

United States Government | Department of Energy

Bonneville Power Administration

memorandum

DATE: January 16, 1998

REPLY TO ATTN OF: TOP

SUBJECT: Columbia Falls Project and Standing Order #310 Upgrades

TO: Mike Kreipe - TOP/SKYPORT

Background:
The United States Bureau of Reclamation (USBR) has planned scheduled upgrades at the Hungry Horse Dam. Presently, the USBR has upgraded the generators (rewind) and increased the peaking capability of Hungry Horse Dam from 328 MW to 428 MW. Ongoing work at Hungry Horse Dam will call for a complete removal of the 115-kV equipment and the completion of a 230-kV ring bus. Prior to the completion of the Columbia Falls Project, which has a scheduled Energization date of November 15, 1997, the USBR will remove from service the existing 115-kV equipment. The USBR has planned to start removing the 115-kV equipment from service in June of 1997. (Please see Appendix A for Planning's recommendations during the interim period from the removal of the 115-kV equipment at Hungry Horse Dam until the energization of the Columbia Falls Project.)

With respect to the scheduled changes at the Hungry Horse Dam, BPA has planned to make necessary modifications at its Columbia Falls Substation. However, due to the necessary changes at Columbia Falls Substation, Standing Order #310 (SO 310) will be reviewed for any necessary modifications. SO 310 balances area load to generation in the Kalispell area and drops Libby generator units to protect against thermal overloads and to maintain stability.

This report provides a summary of steady-state and stability studies that were conducted with an emphasis on maintaining the BPA and WSCC reliability criteria's for the 115-kV and 230-kV networks within the Flathead Valley in relationship to critical single- and double-line outages. Also included is a summary based on the capability of the Conkelley Load Dropping Scheme as of November 15, 1997.

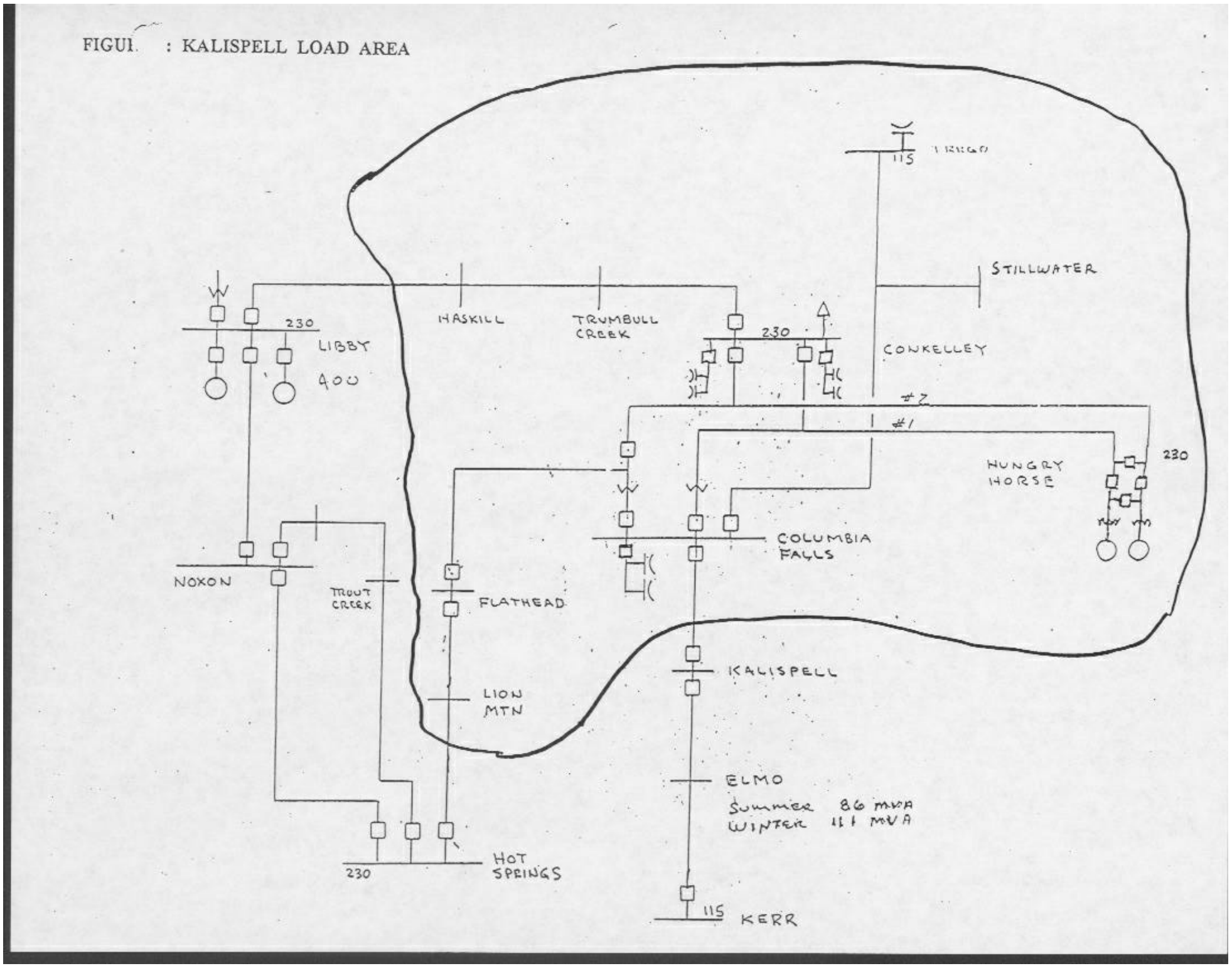
SO 310, with the recommended changes, will give the correct operating direction until 2002. Due to load growth concerns in the Kalispell area, it is suggested that recommendations from this report be limited to a maximum of 5 years. Thereupon, it is suggested that the area be reviewed and further requirements also be limited to a maximum of 5 years.

Kalispell Load Area & Critical lines
The Kalispell load area (does not include Columbia Falls Aluminum Company Load) is considered to be a winter peaking area with estimated normal winter loads in 2002 forecast to be 242 MW. During the summer, the forecast in 2002 is 178 MW.

Following the completion of the upgrades at the USBR's Hungry Horse Dam and the Columbia Falls Project, the following 230-kV lines have been identified as critical lines that feed the Kalispell area;

- Libby - Conkelley 230-kV,
- Noxon - Libby 230-kV,
- Hot Springs - Flathead 230-kV,
- Flathead - Columbia Falls 230-kV, and
- Hungry Horse - Columbia Falls #2 230-kV.

FIGUI : KALISPELL LOAD AREA



Note that, of the 5 critical lines listed above, only 2 of them have the ability to serve load to tap points along the line when one end of the line is open. The lines having the ability to serve load via tap points are:

- Libby - Conkelley 230-kV (Trumbull Creek & Haskill served from Libby or Conkelley solely)
- Hot Springs - Flathead 230-kV (Lion Mountain can be served from Hot Springs or Flathead solely)

In addition to the critical 230-kV lines listed above, the 115-kV networks connected to the Kalispell area are also of concern. The two 115-kV systems of concern are described as follows: to the west of Libby Dam, the 115-kV lines that connect Libby to Bonners via a Libby P - Troy and a Bonners - Troy #1 115-kV lines. Connected via 230/115-kV interconnection at Columbia Falls is another 115-kV network that is part of the Kerr - Trego 115-kV Network.

Presently, the Libby P - Troy 115-kV line, which is owned by PacifiCorp, has a thermal rating of 80 degree C. On the 115-kV network from Kerr to Trego, the thermal loading capability of the 115-kV lines from Kerr to Columbia Falls are of concern. The Kerr - Kalispell 115-kV line section is rated at 100 degree C. However, the line section has summer flow capability of 85 MW and a winter flow capability of 111 MW. Studies have indicated that these 115-kV lines have the potential of being limiting factors at low generation periods.

Due to the enhancement to the generation units at Hungry Horse Dam, the impact of a maximum combined generation output from Libby Dam and Hungry Horse Dam (1028 MW) will be analyzed to determine if there are any **thermal line overload violations** for single-line outages.

WSCC base case files 06A1001.BSE (summer Case ID: A0236.BGY) & 97J2001.BSE (winter Case ID: J01222.BGY) were used to perform the steady-state and stability studies. In the area of concern, BPA calendar year 1996 load forecast (CY96) were used to replace those already in the WSCC base cases. The voltage and flow diagrams of A0236.BGY and J01222.BGY are located in Appendix B

Historical Generation Patterns

The loads within the Kalispell area are served primarily by the USBR's Hungry Horse Dam and by the Army Corps of Engineers (COE) Libby Dam. However, a review of historical generation patterns indicates that there are periods where Libby Dam generation level can be as low as 75 MW and that Hungry Horse Dam generation level can be as low as 5 MW for periods. (See Figure 2a & 2b.) It is during these periods that flows into the area from Hot Springs are critical.

Figure 3 provides the combined generation levels of Libby Dam and Hungry Horse Dam for a 5-year period from 1992 - 1996. This plot indicates there are re-occurring periods in which the combined generation level is below 100 MW. It also indicates there are periods where the combined generation level of Hungry Horse and Libby have exceeded 900 MW.

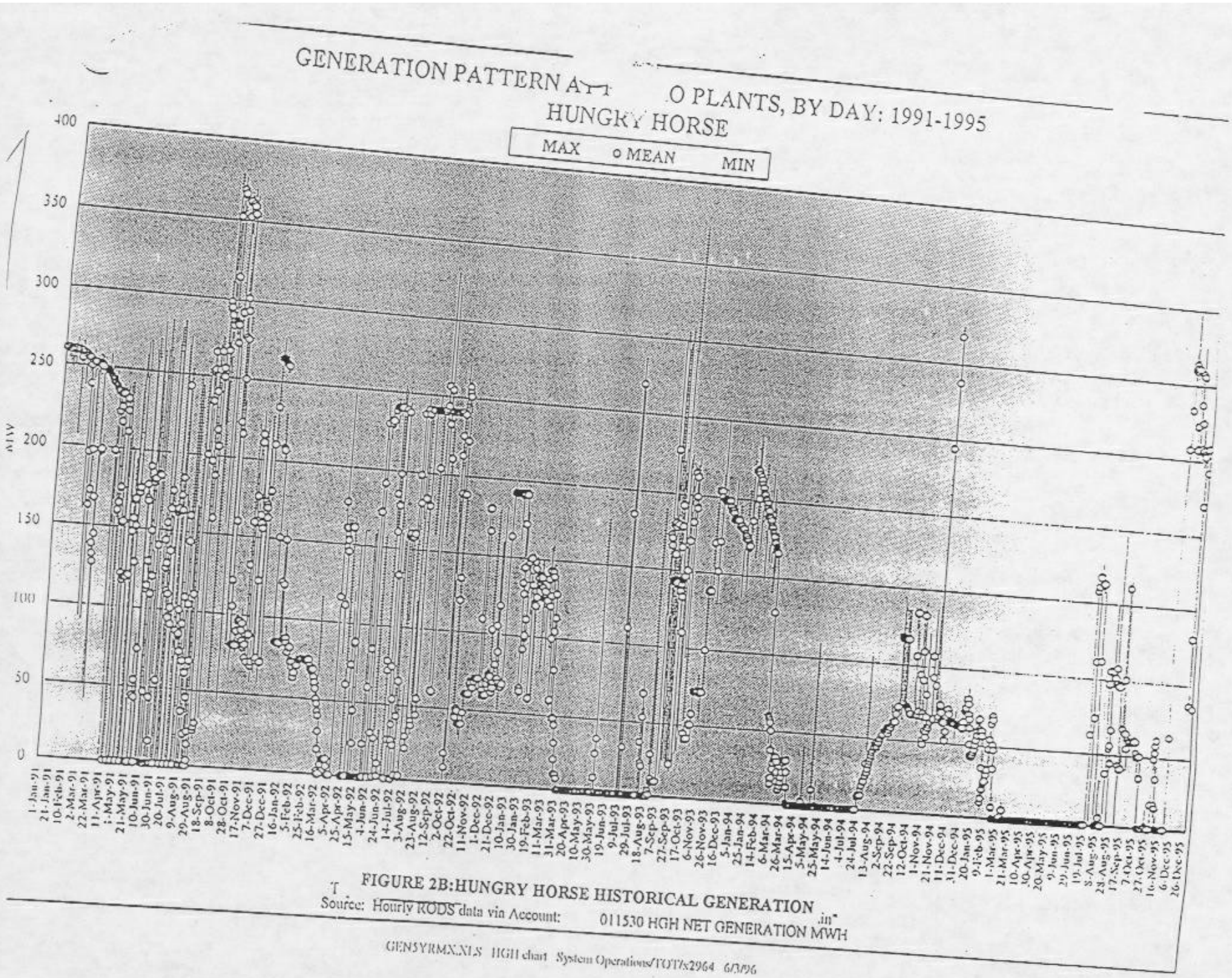
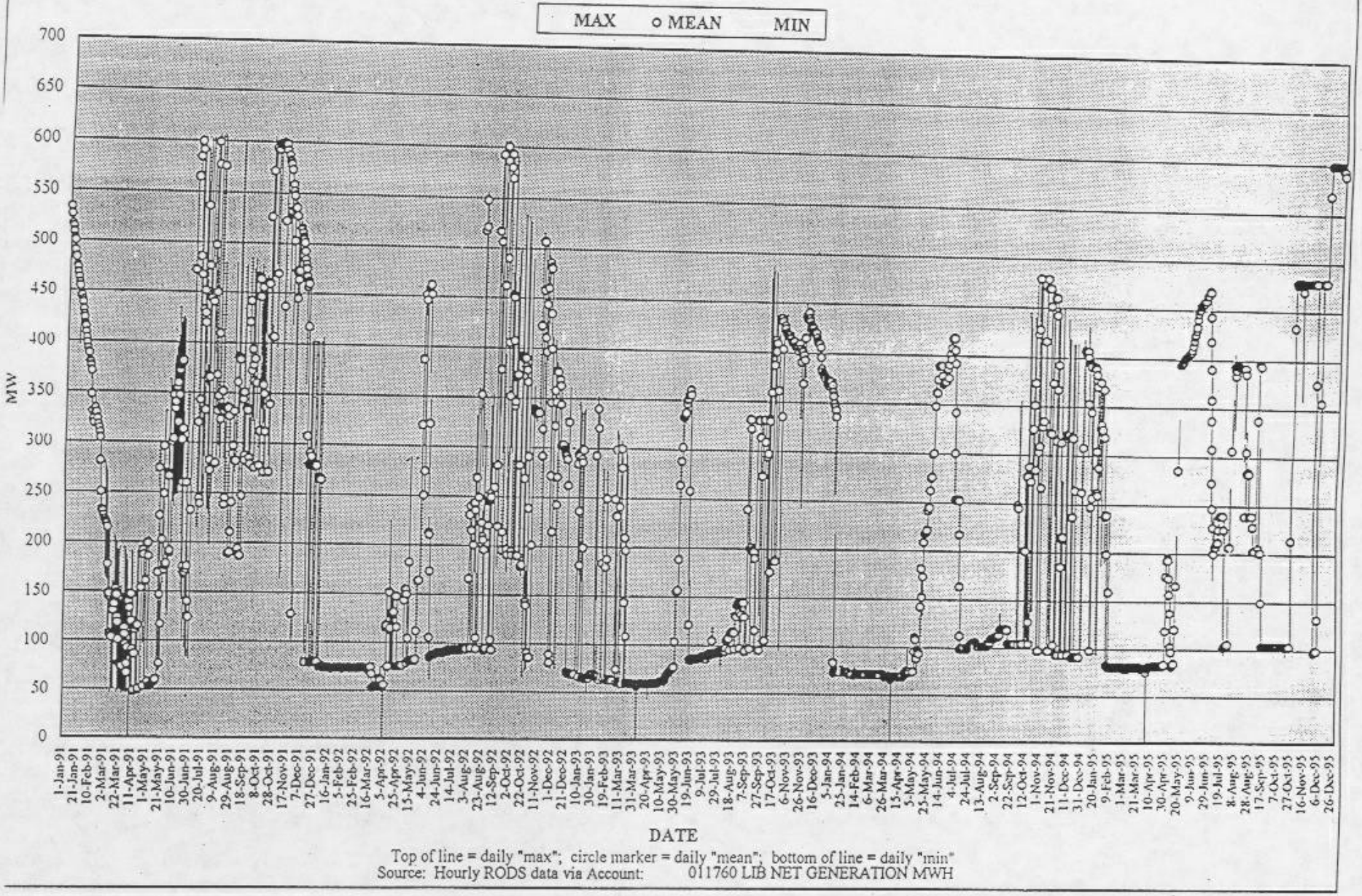


FIGURE 2B:HUNGRY HORSE HISTORICAL GENERATION

Source: Hourly RODS data via Account: 011530 HGH NET GENERATION MWH

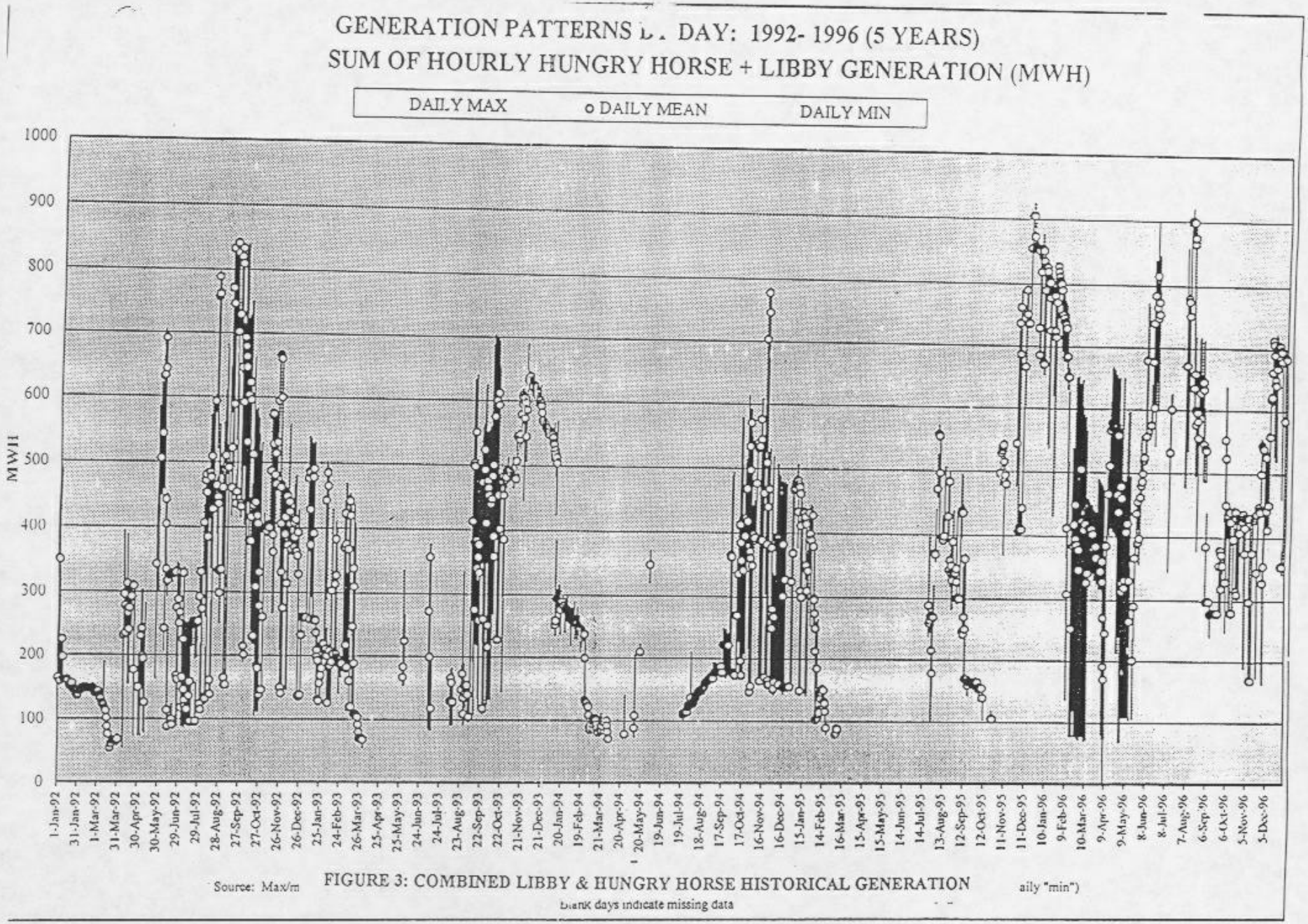
GEN5YRMX.XLS HGH chart System Operations/TOT/x2964 6/3/96

GENERATION PATTERN AT HYDRO PLANTS, BY DAY: 1991-1995
LIBBY



Top of line = daily "max"; circle marker = daily "mean"; bottom of line = daily "min"
Source: Hourly RODS data via Account: 011760 LIB NET GENERATION MWH

FIGURE 2A: LIBBY HISTORICAL GENERATION



Source: Max/m

FIGURE 3: COMBINED LIBBY & HUNGRY HORSE HISTORICAL GENERATION

aily "min")

blank days indicate missing data

XHORSLI1.XLS mx chart System Operations/TOT/x2964 7/2/97

Single-Line Outages Findings & Recommendations

In the steady-state and stability studies conducted on the Kalispell area, it was assumed that the Columbia Falls Aluminum Company (CFAC) load served from BPA's Conkelley substation is at full load of 345 MW.

Steady-State Analysis:

Studies summarized within Table 1, Appendix C, point to the outages of certain critical lines in the Kalispell area that can cause thermal overloads at low generation levels. Table 1 provides a summary of the critical 230-kV line outages and recommendations to obtain a load to generation balance. Table 1 is concentrated on curtailing (dropping) CFAC load at Conkelley which would be an exception to our reliability planning criteria but appears to be contractually acceptable. Other alternatives to tripping Conkelley load during periods of low generation would be to raise generation to acceptable levels or trip other loads within the Kalispell load area to provide a closer load to generation balance. Table 1 can also be used to identify the appropriate generation levels within the Kalispell area needed to serve a desired load level at Conkelley. Raising Hungry Horse generation level is considered as a precautionary action to mitigate the potential loss of the Kalispell load area due to the possible loss of another critical line (double-line outage).

Studies have indicated that, when all lines are in service in the Kalispell area, the loss of the Hot Springs - Flathead 230-kV line can collapse the Kalispell area if the net generation of Hungry Horse Dam and Libby Dam is too low. A sensitivity study of Hungry Horse versus Libby generation with the Hot Springs - Flathead outage was conducted. Diagram 1, which is located in Appendix D, illustrates the sensitivity of area generation to the Hot Springs - Flathead outage with an emphasis on both summer and winter load conditions.

Diagram 1 defines the acceptable combinations of generation at Hungry Horse and Libby for the Hot Springs - Flathead outage. However, before minimum generation levels can be imposed at Hungry Horse and Libby, the Power Business Line of BPA will need to provide input. Efforts have been made to discuss minimum generation levels between the Power Business Line and the Transmission Business Line within BPA. Note: If minimum generation levels cannot be reached, then our contractual agreements to trip load within the Kalispell area should be reviewed.

Studies show that having generator units at Hungry Horse during periods of low generation, spinning unwatered, provides dynamic reactive support to the area that is beneficial in maintaining the area voltage following the event of a single-line outage in the Kalispell area. Each unit dynamic reactive capability is 60 Mvars (240 Mvars total for 4 units). Plot 1, which is located in Appendix D, illustrates the reactive contribution of Hungry Horse units for the Hot Springs - Flathead outage. The analysis associated with Plot 1 and Diagram 1 suggest that a thermal violation occurs on the Kalispell - Kerr 115-kV line prior to a voltage instability problem following the loss of the Hot Springs - Flathead outage.

A study of the loss of the Flathead - Columbia Falls 230-kV line during the summer (30 degree C ambient) at combined generation level of 1028 MW consisting of Hungry Horse and Libby generation, indicates that PacifiCorp's 115-kV 17.1 mile Libby P - Troy reaches 107 percent of its thermal rating. Our records indicate that this line is rated for 80 degree C. An inquiry into the rating of this line and the cost to upgrade this line to 90 degree C is forthcoming.

Stability Analysis:
Stability studies, which took into consideration peak generation at Libby Dam (600 MW) and at Hungry Horse Dam (428 MW), confirmed the present Libby generator dropping scheme for the loss of either the Libby - Conkelley 230-kV or Noxon - Libby 230-kV lines (all but 2 units are tripped automatically). However, due to the additional 100 MW peaking capability at Hungry Horse and the **ability to re-dispatch Libby generation** following the loss of the Libby - Noxon 230-kV line, the PBL and TBL need to address the issue of acceptable Libby generation when the total generation of Hungry Horse and Libby exceeds 550 MW and 650 MW. Efforts have been initiated to have the PBL and TBL resolve this issue.

Double-Line Outages Findings & Recommendations
In the steady-state and stability studies conducted on the Kalispell Area, it was assumed that the Columbia Falls Aluminum Plant load served from BPA's Conkelley substation is at full load of 345 MW. Presently, there are agreements with BPA and the Columbia Falls Aluminum Company (CFAC), which allow BPA to trip CFAC load at Conkelley to maintain stability within the region. This agreement allows for BPA to trip all load or a part of the full load for double contingency outage conditions that would otherwise jeopardize the stability of the region.

The Conkelley load is within the load area. However, for purposes of balancing load within the Kalispell load area to available generation, only CFAC load tripping will be utilized.

Double-Line Outages Steady-State Analysis:
Table 2 provides a summary of the recommendations for the combinations of double-line outages associated with the critical 230-kV lines in the Kalispell Area that were studied. The recommendations are in the form of the revised Schedule A and Schedule B. Of concern is the historical generation patterns at Libby Dam and at Hungry Horse Dam which show that combined generation levels can be low. The double-line outages were evaluated at various generation levels. Table 2 is located in Appendix E and simplifies the results into one page.

Also note Table 2, which is based upon a primary outage condition in the Kalispell area, looking to protect the Kalispell area for the next critical line outage (secondary outage), takes into consideration the most limiting case (worst case scenario). Although area separation is allowable for an outage of two circuits in the area, the recommendation in Table 2 provides improved reliability by raising generation at Hungry Horse after the initial outage. The recommendations are intended to minimize load tripping at CFAC and maximize reliability to the remaining load.

The loss of the Hungry Horse - Conkelley - Columbia Falls #1 and #2 230-kV lines without reducing load or adding more network, yields an unacceptable steady-state response. Note, this finding is not caused by the Columbia Falls Project.

BPA criteria allows for load tripping for the outage described above. However, due to remedial action scheme (RAS) limitations at Conkelley at this time, the RAS is not able to trip the appropriate amount of load at Conkelley for the following sequence: Hungry Horse - Conkelley - Columbia Falls #2 (primary outage) and the Hungry Horse - Conkelley - Columbia Falls #1 (secondary outage). However, the present RAS accommodates for load tripping for the Hungry Horse - Conkelley - Columbia Falls #1 (primary outage) and the Hungry Horse - Conkelley - Columbia Falls #2 (secondary outage).

Historically, for a double-line outage of the Libby - Conkelley and any section of the Hot Springs - Flathead line, loss of the 115-kV connection between Kerr and Columbia Falls almost always occurs. This is understandable because of the great difficulty in balancing area load to generation for all operating conditions. For example, the area load can vary from day to night by as much as 60 MW during the winter and summer. And since the load tripping at Conkelley can only be tripped in blocks of 75 MW , the resulting load variation can exceed the capacity of the 115-kV line.

Taking the history into account, and the large load blocks at Conkelley, it appears that reliability to the loads along the Kerr to Columbia Falls line easily can be improved if we physically trip the Columbia Falls 115-kV breaker (via RAS signal) associated with the Kerr to Columbia Falls 115-kV connection. The backup to the RAS signal would be an over-current relay at Columbia Falls on the Kalispell to Columbia Falls 115-kV line.

Voltage Concerns in Area

For area isolation resulting from the loss of two 230-kV lines in the Kalispell Area that call for all the load to be tripped at Conkelley (Columbia Falls Aluminum Company), extremely high voltages are seen in the area as a result of leaving all shunt capacitors on at Conkelley. The high voltage, due to load characteristics, causes the area load to increase significantly (within the isolated area). The higher area load causes higher flows on the remaining line (Kerr to Columbia Falls 115-kV line) and results in a low voltage swing violation at Kalispell.

From the information provided above, tripping full load at CFAC (345 MW) for an islanded condition, can cause high voltage and a low voltage concerns.

High Voltage Concerns:

One alternative to mitigate high voltage concerns following a force trip of CFAC load (trip via SO 310), is to trip 2 of 4 shunt capacitors at Conkelley in conjunction with the forced trip.

The ability to trip the shunt capacitors in the fashion mentioned above at Conkelley does not exist at this time; however, such a condition that calls for all load to be tripped at Conkelley occurs when Hungry Horse has less than 2 units on-line.

A second alternative is to ensure better active voltage control in area. This can be done by having all available units at Hungry Horse (that are not already in service) brought on line in an unwatered mode to help limit excessive voltage swings. This is the best short-term solution. Specific operational procedures will be determined jointly with Operations.

Low Voltage Concern

The low voltage concern is caused by through flow into the area on the 115-kV network. As noted previously, the option to trip the Columbia Falls 115-kV breaker on the Columbia Falls - Kalispell 115-kV line exists. This solution solves other problems as discussed in the double-line outage section. Therefore, the option of opening the 115-kV breaker at Columbia Falls on the Columbia Falls - Kalispell 115-kV line will be recommended.

Double-Line Outages Stability Analysis:

Table 3 provides a summary of combinations of double-line outages associated with the critical 230-kV lines in the Flathead Valley. After reviewing the stability studies, no new additions based upon stability issues have been identified. Table 3 is located in Appendix F.

SO 310 Arming and Disarming Features

Once the recommendations were determined, it was discovered that SO 310 can only be armed locally. That is, the Conkelley Operator is responsible for arming or disarming SO 310. Presently, SCADA does not have the ability to arm or disarm SO 310. In addition, the **Conkelley Operator (s) are only available Monday thru Friday from 8:00 a.m. - 5:30 p.m..**

Note, the recommendations within this report are based upon the ability of the SO 310 scheme to be armed for the various conditions identified. Presently, measures needed to enable SCADA to arm or disarm SO 310, in addition to a controller arming the appropriate amount of load tripping for critical line outages, are being evaluated (includes outages that the existing RAS at Conkelley is unable to trip load at Conkelley).

Recall, Figure 1 (page #2 of report) provides the outline of the area identified as the Kalispell load area. Note, the Columbia Falls - Kalispell line outage for the forecasted load levels would not be a concern. However, due to recent higher load levels that *have been monitored* at Kalispell associated with Flathead Electric Cooperative and PacifiCorp, maintaining voltage within limits following the outage is a concern. BPA's customer service has been informed of the higher unforecasted loads and we are awaiting information to determine a solution.

Recommendations

1. Revise the existing SO 310 to include the re-configured 230-kV line associated with the Columbia Falls.

   Project and update the load tripping levels to correspond with those given in Table 3 (located in Appendix F).

2. Revise the existing SO 310 to include a RAS signal that will open the 115-kV breaker at Columbia Falls on the Columbia Falls - Kalispell 115-kV line

3. Install an over-current on the 115-kV breaker at Columbia Falls on the Columbia Falls - Kalispell 115-kV line (this will serve as a back-up to SO 310 and provide a higher degree of reliability to the area when SO 310 is unmanned).

4. In the future, any study efforts that address the over-current relay need to take into consideration the dynamic performance of the area following a trip of all CFAC load at Conkelley.

5. Review PacifiCorp load in the area and check compliance with contracts.

6. Develop Hungry Horse unwatered operation procedure(s) with Operations.

Gordon J. Young
Project Engineer

Attachments

cc:
R. Spence - TOON/DITT-2 (with attachments)
Mark Bond - TOP/SKYPORT (w/o attachments)
Marv Landauer - TOP/SKYPORT (w/o attachments)
Official File - TOP (ED-12-3) (with attachments)

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